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Charles W. Stewart

Date: August ~~26~~ 27, 2003

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	
RASHMI K. SHAH et al.	
Serial No. 09/168,770	Group Art: 1764
Filed October 8, 1998	Examiner: Basia A. Ridley
FLAMELESS COMBUSTOR PROCESS HEATER	August 26, 2003

COMMISSIONER FOR PATENTS
P. O. Box 1450
Alexandria, VA 22313-1450

Sir:

APPELLANT'S AMENDED BRIEF

The following amended brief is filed in support of Applicant's appeal from the Examiner's action dated January 2, 2003, finally rejecting claims 1-7 and 13-24, which are all of the claims remaining in the above-identified U.S. patent application. A notice of appeal was mailed by Applicant on April 11, 2003, followed by an appeal brief, which was mailed on May 20, 2003. However, the appeal brief was refused entry by the Examiner because, according to the Office Communication of August 1, 2003, it failed to comply with 37 CFR 1.192 (c) in that "The Appellant has not presented any arguments regarding the rejections based on Fig. 1 of Ruhl in view of Mikus or regarding rejections based on Fig.1 of Ruhl in view of Mikus and further in view Minet et al., which are the only rejections of record".

Appellant did in fact present some arguments on page 10 lines 17-26 of the May 20, 2003 brief as to why the apparatus in Fig. 1 of Ruhl was not relevant to the claimed flameless

distributed combustion process heater. However, Appellant incorrectly assumed that the rejections of record were primarily based on the reaction apparatus in Fig. 4 of Ruhl, which Appellant considered more relevant than the apparatus of Fig. 1. Appellant is grateful to the Examiner for clarifying that the only rejections of record are based on Fig. 1 of Ruhl in combination with Mikus (or Fig.1 in combination with Mikus and Minet et al in the case of claims 17 and 24), and that Fig. 4 is not being relied on for any of the rejections. In view of the significance the Examiner apparently places on the reaction apparatus of Fig. 1 of Ruhl, Appellant has expanded the discussion of Fig. 1 in this amended brief, and has also expanded Appellant's arguments as to why the rejections based on Fig. 1 of Ruhl are untenable and should be reversed.

Please charge the fee for filing this amended brief (which is being filed in triplicate) to Shell Oil Company Deposit Account No. 19-1800.

It is respectfully requested that the Board reverse the final rejection of claims 1-7 and 13-24 of the above-identified application for the reasons discussed below as supported by the cited authorities.

REAL PARTY IN INTEREST

The invention described and claimed in the above-identified patent application is assigned to Shell Oil Company, which is the real party in interest in the present appeal.

RELATED APPEALS AND INTERFERENCES

Appellant and Appellant's legal representatives, are not aware of any appeals or interferences that directly affect or could be directly affected by or have a bearing on the Board's decision in the present appeal.

STATUS OF AMENDMENTS

The amendments proposed in Appellant's response after final rejection were entered by the Examiner. There are no outstanding amendments with respect to the present application.

SUMMARY OF THE INVENTION

The present invention relates to a flameless distributed combustion process heater apparatus for providing heat to high temperature reactions at a desired temperature profile and a controlled heat flux at a sufficiently high rate to complete the process being conducted in the process chamber of said process heater apparatus. The flameless distributed combustion process heater apparatus of the present invention comprises three basic elements:

(1) An oxidation chamber containing a fuel conduit with a plurality of nozzles distributed along substantially the entire length of the oxidation chamber. The nozzles are spaced to produce combustion without a flame (i.e., "flameless" combustion) when fuel is mixed with preheated oxidant in the oxidation chamber.

(2) A preheater for heating oxidant to a temperature that when the oxidant and fuel are mixed in the oxidation chamber, the temperature of the resulting mixture will exceed the autoignition temperature of said mixture.

(3) A process chamber in a heat exchange relationship with the oxidation chamber whereby a controllable heat flux is provided to the process chamber at a sufficiently high rate to complete the process being conducted therein.

Various high temperature reactions such as the steam reforming of hydrocarbons, dehydrogenation of ethyl benzene to produce styrene, and the like, can be conducted in the process chamber.

The spacing of the fuel nozzles and the distribution of the fuel nozzles along substantially the entire length of the oxidation chamber results in flameless, distributed combustion in the oxidation chamber, which provides a controllable heat flux to the process chamber at a sufficiently high rate to complete the process being conducted therein. The heat flux may be controlled to provide a uniform temperature profile, but can also provide increasing or decreasing temperature profiles.

A basic advantage of the present invention is that the temperature profile, or flux of heat, may be controlled to whatever temperature profile is desired for a particular reaction. (Specification, page 6, lines 9-13) The benefits of the flameless distributed combustion process heater of the present invention include higher temperatures within metallurgical constraints, improved conversions, improved selectivities and/or product yields, reduced by-product production, reduced risk of tube failures due to "hot spots", lower energy consumption and low NO_x emissions. (Page 4 of specification, line 26, to page 5, line 9.)

The specific limitations being relied on to distinguish over the cited references include the limitations that "a plurality of fuel nozzles" be distributed "along substantially the entire length of the oxidation chamber", that the fuel nozzles are "spaced so that the fuel is added to the oxidation chamber at a rate that no flame results when fuel is mixed the oxidant" in the oxidation chamber, and that "a controllable heat flux is provided to the process chamber at a sufficiently high rate to complete the process being conducted therein" These limitations are included in independent claim 1 and the claims depending therefrom.

Claim 18, the only other independent claim, and the claims depending therefrom, contain the limitations that the fuel conduit contain "a plurality of fuel nozzles distributed along substantially the entire length of the oxidation chamber", that the fuel nozzles be spaced so that

the flow of fuel through the fuel nozzles "results in no flame" when the fuel passes through th nozzles and is mixed oxidant in the oxidation chamber, and that "said plurality of nozzles distributed along substantially the entire length of said oxidation chamber being siz d to provide the desired temperature distribution within said process chamber and the heat flux necessary to complete the process being conducted therein".

ISSUES

Whether claims 1-7, 13-16 and 18-23 are unpatentable under 35 U.S.C. §103 (a) over Ruhl (EP 0450 872) in view of Mikus (USP 5,255,742).

Whether claims 17 and 24 are unpatentable under 35 U.S.C. §103 (a) over Ruhl (EP 0 450 872) in view of Mikus (USP 5,255,742) and further in view of Minet et al (USP 4,692,306).

GROUPING OF CLAIMS

Claims 1-7, 13-16 and 18-23 stand or fall together. Claims 17 and 24 do not stand or fall with the other claims, but are believed to be separately patentable by virtue of the limitation that the oxidant flowing through the flow path in the oxidation chamber " is preheated by heat exchange with effluent from the process chamber". This separately patentable embodiment is not taught or suggested by any of the cited references as hereinafter discussed.

ARGUMENTS

THE REJECTION OF CLAIMS 1-7, 13-16 AND 18-23 UNDER 35 USC 103(a) OVER RUHL IN VIEW OF MIKUS

In the Office action mailed January 2, 2003, the Examiner finally rejected claims 1-7, 13-16 and 18-23 under 35 U.S.C. §103 (a) as being unpatentable over Ruhl in view of Mikus. In the following section Appellant will discuss (1) The teachings of the Ruhl and Mikus references taken as a whole, (2) the position taken by the Examiner regarding these references, the bases given for combining the references to reject the aforementioned claims, and (3) Appellant's comments and arguments in response to each of the Examiner's positions and bases for rejection.

The Ruhl Reference Taken as a Whole

Ruhl discloses various apparatuses for effecting endothermic reactions such as reforming light-hydrocarbons (Pg. 4 lines 11-13). The reaction apparatuses of Ruhl include a reaction vessel for effecting an endothermic reaction, having an inlet for feeding the feed gas mixture into the reaction vessel, a discharge for removing product gas, and at least one heat

generating means which is enclosed by the reaction vessel and provides heat to the reaction vessel which may contain a catalyst bed (Pg. 3, line 56 to pg. 4, line 1). The heat generating means comprises at least one ceramic combustion tube concentrically surrounding a fuel feed tube which extends at least partially along the length and inside of the combustion tube. The heat generating means has inlets for supplying fuel gas and air. The fuel gas an air are combusted in the heat generating means and the heat which is generated is transferred into the reaction vessel to facilitate the endothermic reaction to produce a product gas (Pg. 4, lines 2-6).

Of the various apparatuses depicted in Figs. 1-5 of Ruhl, all except the apparatus depicted in Fig. 4 show combustion <u>with flames</u>. The apparatus in Figure 1, for example, clearly shows a flame in flame zone 50. The apparatus depicted in Fig. 4 does not show a flame and therefore, arguably, utilizes flameless combustion, although the term "flameless combustion" is not used anywhere in the Ruhl reference.

The heat generating means shown in Figure 1 of Ruhl (combustion tube 30), in addition to using <u>combustion with flames</u>, does not have a fuel conduit <u>with a plurality of nozzles</u>. Instead, fuel feed tube 34 (which is located inside of combustion tube 30) has a <u>single</u> opening or nozzle at the end of the feed tube through which the fuel passes, whereupon it is mixed with air and ignited in flame zone 50. (See Fig. 1 of Ruhl).

Since flame zone 50 in Fig.1 of Ruhl is located approximately in the middle of combustion tube 30, it is clear that the temperatures in the lower portion of combustion tube 30 (below the flame zone) and in the upper portion of combustion tube 30 (above the flame zone) will be lower than the temperatures in the flame zone per se. This will result in an uneven or non-uniform temperature profile in combustion tube 30, and correspondingly the provision of an uneven or non-uniform heat flux to packed bed 20.

Lower temperatures in the upper and lower portions of combustion tube 30 are desired by Ruhl because combustion tube 30 is sealed at the ends to plates 16 and 18 by seals 32 (which preferably are low temperature seals such as “a graphite foil spiral wrapped annular cylinder seal”) which holds the combustion tube in place (Pg. 4, lines 39-44). One of the stated advantages of the reaction apparatus of Ruhl is that it “allows for the use of relatively low temperature seals” (Pg. 3, lines 54-55). On page 4, lines 48-49 of Ruhl, it is stated that “A feature of the present design is that it allows for the use of lower temperature seals where the combustion tube or tubes are joined to the tube sheet.”

Of the various apparatuses shown in Fig. 1-5 of Ruhl, only Fig.4 has a feed gas tube with a plurality of perforations or holes 64 which are spaced at intervals along its length in burner zone 68. However, burner zone 68 represents <u>only a minor portion (appears to be roughly 20%)</u> of the overall length of combustion tube 30. Similar to the apparatus in Fig. 1, there are no perforations or holes in the upper or lower portions of combustion tube 30 in Fig. 4.

Therefore, the temperatures in these portions will be lower than the temperature in the "burner zone", thus allowing the use of low temperature seals. It is also noted, that the feed gas tube in Fig. 4 has one end plugged or otherwise closed. It is stated in Ruhl "that plug 66 need not resist very hot temperatures and thus could be made of graphite or heat resistant organic cement." (Pg. 5, lines 55-56). This further supports the fact that the upper portion of combustion tube 30 in Fig. 4 (which contains the plugged end of the fuel tube) will have lower temperatures than the middle portion of the combustion tube in which the "burner zone" is located. This will result in the provision of an <u>uneven or non-uniform heat flux</u> to the process being conducted in the reaction vessel, with more heat being provided to section of packed bed 20 surrounding the "burner zone", than to the sections of the packed bed surrounding the upper or lower portions of combustion tube 30.

Thus, neither the heater (combustion tube 30) in Fig. 1 of Ruhl, nor the heater (combustion tube 30) in Fig. 4 of Ruhl is designed to provide an "even" or "uniform" heat flux to the process being conducted in the reaction vessel. Moreover, there is no teaching or suggestion in Ruhl that an "even" or "uniform" temperature distribution is desired. To the contrary, Ruhl teaches that lower temperatures are desired in the upper and lower portions of the combustion tube to allow the use of relatively low temperature seals.

<u>The Mikus Reference Taken as a Whole</u>

The Mikus reference discloses a method for injecting heat into a subterranean formation of low permeability, such as diatomites and oil shale, to enhance the recovery of oil (Col.1, lines 9-19). The disclosed heat injection method uses a fuel gas combustor which does not require a flame in the borehole during the heating process (Col. 3, lines 1-5). The absence of flame eliminates the flame as a radiant heat source and results in a more even temperature distribution throughout the length of the burner (lines 3-5 of the abstract). The disclosed method for heating a subterranean formation requires a borehole from the surface to the subterranean formation and includes the steps of: (1) Combining a hydrocarbon fuel gas with a carbon formation suppressant; (2) passing the fuel gas and carbon formation suppressant mixture through a fuel gas conduit to a mixing point juxtapose to the formation to be heated; (3) passing a combustion air stream through an air conduit to the mixing point; (4) preheating either the fuel gas and carbon suppressant mixture, the combustion air stream or both, such that the temperature of a mixture of the streams exceeds the autoignition temperature of the mixture of streams; (5) combining the preheated combustion air and fuel gas and carbon suppressant at the mixing point resulting in autoignition forming combustion products; and (6) passing the combustion products through the borehole from the mixing point to the surface. (Col. 3, lines 12-36). The heat injectors shown in Figs. 1-5 of Mikus all have in common, a fuel gas conduit 12 having a plurality of orifices 13, an air conduit 10, with the fuel gas conduit and air conduit both

being situated in a casing cemented into wellbore using a high temperature cement. The combustion products either travel up the well bore and out an exhaust nozzle at the wellhead as in Figs. 1 and 4, or through a separate combustion gas conduit 19 as in Figs. 2, 3 and 5. The plurality of orifices in Mikus are sized to accomplish nearly even temperature distribution in the casing. A nearly even temperature profile in the casing results in more uniform heat distribution within the formation to be heated. (Col. 5, lines 46-51). While not specifically stated in Mikus, it would be known to one skilled in the art that fuel gas conduit, air conduit and combustion gas conduit in Mikus could be hundreds or even thousands of feet in length depending on the depth of the subterranean formation to be heated. Only a small portion of the overall length of the feed gas conduit would have fuel nozzles, i.e., the lower portion of the feed gas conduit within the formation to be heated. (Col. 5, lines 41 -43).

Mikus teaches that the heat is removed from the combustion chamber of the heat injectors at the relatively low heat flux rate of 375 watts per foot of length. (Col.9, lines 67-68 to col. 10, line 1).

Thus, the heat injector in Mikus is designed to inject heat at a relatively low heat flux and a nearly even temperature profile into subterranean formations to uniformly increase the temperature of the formation to enhance oil recovery. Unlike the heater used in the endothermic reaction apparatuses of Ruhl or the flameless distributed combustion process heater of the present invention, the heat injector in Mikus <u>is not a process heater.</u> There is no process chamber or reaction chamber for conducting an endothermic reaction in the apparatus of Mikus.

<u>The Rejection Based on Ruhl in View of Mikus</u>

Claims 1-7, 13-16 and 18-23 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Ruhl in view of Mikus.

<u>Examiner's Position re Ruhl</u>

In the last paragraph on page 8 and the first paragraph of 9 of the January 2, 2003 Office action it is stated that:

> "Regarding claim(s) 1 and 18, Ruhl, in Fig. 1 disclose(s) a process heater comprising:
>
> - an oxidation chamber (30) having an inlet (40) for oxidant, an outlet (54) for combustion products and a flow path (30) between the inlet (40) and the outlet (54);
> - a fuel conduit (34) capable of transporting a fuel mixture to a fuel nozzle (Fig. 1) within the oxidation chamber (30), said nozzle providing communication from within the fuel conduit (34) to the oxidation chamber (30);
> - a preheater in communication with the oxidation chamber inlet (P5/L41-46); and
> - a process chamber (20) in a heat exchange relationship to the oxidation chamber (30).
>
> While Ruhl shows embodiments of his heater which operate without a flame (see Fig. 4), such operation is not disclosed with respect to Fig. 1."

Appellant's Comments/Arguments In Response to the Examiner's Position re Ruhl

In Appellant's brief of May 20, 2003, Appellant incorrectly assumed that the rejections of record were for the most part based on the apparatus shown in Fig. 4 of Ruhl, which appeared to Appellant to be more relevant than the apparatus in Fig. 1 of Ruhl, since the apparatus of Fig. 1 didn't have a fuel conduit with a plurality of fuel nozzles and clearly shows a flame in flame zone 50. (All of the appealed claims require *inter alia* a fuel conduit having a plurality of fuel nozzles and that the nozzles be spaced so that no flame results when fuel is mixed with oxidant.)

In the Office Communication mailed August 1, 2003, the Examiner clarified that the only remaining rejections of record were based on Fig. 1 of Ruhl in combination with Mikus (or Mikus and Minet et al in the case of claims 17 and 24), that the rejection based on Fig. 4 had been overcome and that Fig. 4 was not being relied on for the remaining rejections.

In accordance with the August 1, 2003 Office Communication, the following comments on Ruhl will be primarily directed to the reaction apparatus shown in Fig. 1 of Ruhl. However, the comments contained in the previous brief relating to the reaction apparatus of Fig. 4 have not been entirely deleted, even though the Examiner does not consider them germane to the rejections of record. Since a reference must be considered as a whole, it is deemed relevant that the appealed claims were found to be patentable over the reaction apparatus of Fig. 4 of Ruhl (which is the only apparatus in Ruhl having a fuel conduit with a plurality of fuel nozzles and not showing a flame).

Comments/Arguments re Apparatus in Fig. 1 of Ruhl

Two critical features recited in each of the appealed claims are that fuel conduit contain a plurality of nozzles distributed along substantially the entire length of the oxidation chamber, and that fuel nozzles are spaced so that no flame results when fuel is mixed with oxidant in the oxidation chamber. The apparatus in Fig. 1 of Ruhl does not contain a plurality of fuel nozzles and clearly shows a flame in flame zone 50. Instead of a plurality of nozzles, the fuel feed tube 34 in Fig. 1 has a single opening or nozzle at the end of the feed tube 34 through which the fuel passes, whereupon the fuel is mixed with air and ignited in flame zone 50 resulting in combustion with flames.

Since flame zone 50 in Fig.1 of Ruhl is located approximately in the middle of combustion tube 30, it is clear that the temperatures in the lower portion of combustion tube 30 (below the flame zone) and in the upper part of combustion tube 30 (above the flame zone) will be lower than the temperatures in the flame zone per se. This will result in an uneven or non-

uniform temperature profile in combustion tube 30, and correspondingly the provision of an uneven or non-uniform heat flux to packed bed 20.

Lower temperatures in the upper and lower portions of combustion tube 30 are in fact desired by Ruhl because Ruhl prefers the use of relatively low temperature seals such as graphite seals to hold the combustion tube in place. (Pg. 4, lines 39-44). One of the stated advantages of the reaction apparatus of Ruhl is that it "allows for the use of relatively low temperature seals" (Pg. 3, lines 54-55). On page 4, lines 48-49 of Ruhl, it is stated that "A feature of the present design is that it allows for the use of lower temperature seals where the combustion tube or tubes are joined to the tube sheet."

Comments/Arguments re Apparatus in Fig. 4 of Ruhl

The apparatus in Fig. 4 of Ruhl is somewhat more relevant than the apparatus in Fig. 1, in that at least the fuel feed tube has a plurality of nozzles. However, the plurality of nozzles in Fig. 4 are located in the middle portion of the combustion tube 30 in "burner zone" 68, which represents only about 20% of overall length of the combustion tube. In marked contrast, the claims under appeal require the nozzles to be distributed along substantially the entire length of the oxidation chamber. Because of the location of the fuel nozzles in burner zone 68, this portion of combustion tube 30 will transfer more heat to packed bed 20 than the upper portion of the combustion tube or the lower portion of combustion tube 30, which contain no fuel nozzles. As discussed above, lower temperatures are desired by Ruhl in the upper and lower portions of combustion tube 30 because of the preference to use low temperature seals. Also, the upper portion of combustion tube 30 surrounds a feed gas tube which is plugged with a material that "need not resist very hot temperatures" (Pg. 5, lines 55-56).

Summary of Comments/Arguments re Ruhl

One of ordinary skill in the art following the teachings of Fig. 1 of Ruhl would use combustion with flames in a flame zone in the middle of the combustion tube, and would use a fuel tube with a single nozzle at the end of the tube. One skilled in the art following the teachings of Fig. 1 would also want lower temperatures in the upper and lower portions of the combustion tube in order to permit the use of low temperature seals.

One of ordinary skill in the art following the teachings of Fig. 4 of Ruhl would place a plurality of fuel nozzles in the "burner zone" in the middle portion of the combustion tube in order to optimize the process and would want lower temperatures in the upper and lower portions of the combustion tube in order to permit the use of low temperature seals and a plug for the feed tube that "need not resist very hot temperatures".

The significant benefits achieved by using a plurality of fuel nozzles located along substantially the entire length of the oxidation chamber in order to provide a controlled heat flux to the process chamber is taught in Applicant's patent application, not in Ruhl or the other cited references. The use of Applicant's teachings to modify the prior art to arrive at th claimed invention would, of course, be impermissible hindsight reconstruction. *Hodosh v Block Drug Co. Inc.* 786 F.2d 1136, 1143 n.5 USPQ 182 n.5 (Fed. Cir. 1986).

Examiner's Position re Mikus

On page 9 of the January 2, 2003 Office action it is stated that:

"Mikus, in Fig. 3 teaches a process heater comprising:

- an oxidation chamber (10) having an inlet for oxidant, an outlet for combustion products and a flow path between the inlet and the outlet (Fig. 3);
- a fuel conduit (12) capable of transporting a fuel mixture to a plurality of fuel nozzles (13) within the oxidation chamber (10), each nozzle (13) providing communication from within the fuel conduit (12) to the oxidation chamber (10), with each nozzle (13) along the flow path between the inlet and the outlet; and
- a preheater in communication with the oxidation chamber inlet, the preheater capable of increasing the temperature of the oxidant and the fuel from the fuel nozzle closest to the oxidation chamber inlet being hotter than the autoignition temperature of the combined oxidant and fuel from the fuel nozzle closest to the oxidation chamber inlet (C3/L25-30).

In said process heater preheating at least the air stream and then mixing the fuel gas into the combustion air in relatively small increments will result in the flameless combustion (C4/27-40). The absence of flame eliminates the flame as a radiant heat source and results in more even temperature distribution throughout the length of the burner (abstract). Further it eliminates the hot spots within the burner and structures surrounding the burner, which originate from the radiant heat transfer from the luminous portion of the flame. Said process heater not only optimizes the process operation but is also less expensive than a process heater operating with flames because of less expensive materials of construction (C2/L4-12)."

Appellant's Comments/Arguments In Response to the Examiner's Position re Mikus

Appellant believes the Examiner's characterization of the heat injector in Mikus as a "process heater" is incorrect and reflects a possible misunderstanding of the present invention. The term "process heater" as used in the present specification and claims refers to a heater used to provide a controlled heat flux to an endothermic chemical process conducted in a process chamber, which is an essential element of the Appellant's process heater apparatus. The heat injector in Mikus has no "process chamber". It is simply used to inject heat into a subterranean formation at a relatively low heat flux, e.g., 375 watts per foot of length. (Col. 9, lines 67-68 to col. 10, line 1) to enhance oil recovery. As stated in the Affidavit by Dr. Thomas Mikus, filed with Appellant's August 19, 2002 Response, heaters employed to heat endothermic

chemical processes of the type described in th present application require significantly greater amounts of heat, .g. 3,500 to 7,000 watts per foot, compared to the 375 watts per foot heat flux required to heat the rocky materials found in subterranean formations, which materials are very good insulators.

Thus, while the heat injector used by Mikus to heat subterranean formations may contain some of the same elements as the process heater of Appellant's invention, it is not a process heater, it does not have a process chamber, and it is directed to a quite different problem, i.e., injecting heat at a relatively low heat flux into rocky materials which are good insulators. In contrast, the process heater apparatus of the present invention is directed to the problem of providing heat at a relatively high heat flux to flowing process streams which rapidly carry heat away from the heat source. In the process heater of the present invention, this is accomplished *inter alia* by distributing the plurality of nozzles along substantially the entire length of oxidation chamber which is in heat transferring contact with the process chamber.

The Examiner acknowledges on page 10 of the January 2, 2003 Office Action that Mikus, like Ruhl, does not explicitly disclose nozzles being distributed along substantially the entire length of the oxidation chamber. Instead the plurality of orifices in Mikus are distributed "along the length of the conduit within the formation to be heated" and the "orifices are sized to accomplish nearly even temperature distribution within the casing." This results in "a nearly uniform heat distribution within the formation." (Col. 5, lines 41-53).

Examiner's Position re Basis for Combining Ruhl with Mikus

The Examiner's basis for combining Ruhl with Mikus is stated on page 10 of the January 2, 2003 Office action. According to the Examiner:

> "It would be obvious to one of ordinary skill in the art at the time the invention was made to replace the heater in the apparatus of Ruhl with the heater of Mikus for the purpose of providing more even temperature distribution throughout the length of the burner and lowering the costs of said apparatus."

Appellant's Comments/Arguments as to Why Ruhl is Not Properly Combinable with Mikus

It basic patent law that the mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 USPQ 2d 1430 (Fed. Cir. 1990). Although a prior art device "may be capable of being modified to run the way the apparatus is claimed, there must be a suggestion or motivation in the reference to do so." 916 F.2d at 682, 16 USPQ2d at 1432.

Appellant submits that in the present case, there is no suggestion or motivation in th Ruhl or Mikus references for modifying them in the manner the Examiner has done. The Examiner's position that it would be obvious "to replace the heater in the apparatus of Ruhl with the heater of Mikus for the purpose of providing more even temperature distribution throughout the length of the burner and lowering the costs of said burner" is based on the erroneous assumption that an "even" or "uniform" temperature distribution throughout the length of the burner, which is taught by Mikus to be beneficial in heating subterranean formations, is also beneficial in heater used by Ruhl to provide heat to his endothermic reaction apparatus. This assumption is not correct, and in fact contrary to the disclosure in Ruhl.

As previously discussed, the heater (combustion tube 30) in the apparatus in Fig. 1 of Ruhl <u>does not have a "even" or "uniform" temperature distribution along the length of the combustion tube</u>, nor is there any teaching that an "even" or "uniform" temperature distribution is desired. To the contrary, Ruhl prefers the use of low temperature seals to hold the combustion tube in place. Therefore, the combustion tube in Fig. 1 of Ruhl intentionally has the highest temperatures in flame zone 50 (in the middle of combustion tube 30), with lower temperatures at the upper and lower portions of the combustion tube to allow the use of low temperature seals to join the combustion tube to the tube sheets.

Likewise the heater in Fig. 4 of Ruhl does not have an "even' or "uniform" temperature distribution since all of the fuel nozzles in Fig. 4 are in the "burner zone" 68 in the middle portion of combustion tube 30. There are no fuel nozzles in the upper portion or lower portion of the combustion tube 30. Consequently, these portions will have lower temperatures than the temperature in the "burner zone" 68, thereby allowing the use of low temperature seals. Lower temperatures in the upper portion of combustion tube also allows the use of a plug 66 at the upper end of the fuel tube "which need not resist very hot temperatures".

Since the heaters in both Fig. 1 and Fig. 4 of Ruhl by design have a <u>non-uniform</u> temperature distribution along their length, and since there's no indication in Ruhl that an "even" or "uniform" temperature distribution is desirable, <u>it would not be obvious</u> to one skilled in the art to replace the heater in the apparatus of Ruhl with the heater in Mikus for "the purpose of providing more even temperature distribution throughout the length of the burner", as contended by the Examiner. The teaching or suggestion to combine these references and a reasonable expectation for success <u>must both be found in the prior art</u>, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20USPQ2d 1438 (Fed. Cir. 1991). Appellant submits that in the present case the prior art does not suggest replacing the heater in either Fig. 1 or Fig. 4 of Ruhl with the heat injector in Mikus, nor does the prior art create a reasonable expectation that such substitution would be successful.

The fact that the heaters used in Figs. 1 and 4 of Ruhl have a non-uniform temperature distribution along their length, while the heater in Mikus is designed to produce an "even" or "uniform" temperature distribution, again illustrates the differences between the problems to which Ruhl and Mikus were directed, and why these references are not properly combinable. Ruhl wanted to design a reactor apparatus with a heater which could provide a high heat flux sufficient to complete the particular endothermic reactions he was interested in, yet low temperature seals could be used in the reactor to connect the combustion tubes to the tube sheets. Therefore, Ruhl designed combustion tube 30 to have lower temperatures in the general vicinity of the seals with higher temperatures in the middle of the heater (i.e., in "flame zone" 50 in the case of Fig.1, and in "burner zone" 68 in the case of Fig. 4).

Mikus, on the other hand, was concerned with recovery of hydrocarbons and found that the provision of uniform heat to underground formations, at a relatively low heat flux, was highly beneficial. Mikus was not concerned with designing compact reaction apparatuses, or conducting endothermic chemical reactions which require a high heat flux, or joining combustion tubes to tube sheets with low temperature seals. Since the problems to which Ruhl and Mikus are directed, and the solutions they found, are quite different, it clearly would not be obvious to replace the heater in Ruhl with the heater of Mikus " for the purpose of providing more even temperature distribution throughout the length of the burner". Such substitution would not solve the problems to which Ruhl was directed, nor achieve the benefits Ruhl desired.

Appellant further submits that it would not be obvious to replace the heater in the apparatus of Ruhl with the heater of Mikus for the purpose of "lowering the costs of said apparatus". The heater in Fig. 1 utilizes combustion with flames, which will generate a high temperature in the flame zone, and lower temperatures in the upper and lower portions of the combustion tube which permits the use of low temperature seals to join the combustion tubes to the tube sheets. It is doubtful that substituting the relatively low heat flux flameless heater of Mikus for the flame-type heater used in the apparatus of Fig.1 of Ruhl would provide sufficient heat flux to complete the desired endothermic reactions. If it did, it is likely that the temperatures in the upper and lower portions of the combustion tubes would be too high to use the low temperature seals favored by Ruhl. Thus, the substitution of heaters suggested by the Examiner would involve a significant redesign of the reactor apparatus in Fig. 1 of Ruhl, and may necessitate the use of high temperature seals, which could actually increase the cost of the apparatus.

Appellant submits that when the Ruhl and Mikus references are considered as a whole, rather that suggesting to one skilled in the art to replace the heater of Ruhl with the heat injector of Mikus, they provide at least two significant reasons for not replacing the heater of Ruhl with the heat injector of Mikus. (1) The heaters used to provide heat to the endothermic reaction

apparatus s in Figs. 1 and 4 of Ruhl hav a non-uniform temperature distribution by design, and there is no indication that an even temperature distribution is desired, and (2) endothermic chemical reactions, such as the reforming of light hyrdocarbons, which are of interest to Ruhl, require far greater heat flux than the approximately 375 watts per foot produced by the heater injectors used by Mikus to heat subterranean formations, as stated in the affidavit by Dr. Mikus, to which the Examiner refused to give any weight.

Appellants Comments/Arguments re Examiner's Refusal to Give Appropriate Weight to the Affidavit by Dr. Mikus'

Appellant filed an affidavit by Dr. Thomas Mikus (the inventor on the Mikus reference and a co-inventor on the present application) with Appellant's response of August 19, 2002. In the affidavit Dr. Mikus explained that the heat injector disclosed in the Mikus reference was developed to replace electric line heat source heaters and was seen as a uniform low, linear source heater, that typically provided only about 375 watts per foot heat flux along the length of the well. (See page 2 of the Affidavit by Dr. Mikus, and col. 9, line 67 to col.10, line13 of the Mikus reference). Dr. Mikus further explained that endothermic chemical processes required an order of magnitude greater heat flux requirement (e.g., 3,500 to 7,000 watts per foot for a process for the production of ethylene by the thermal cracking of hydrocarbons) because flowing process streams carry away heat from the heat source far more rapidly than the rocky materials found in subterranean formations.

In the January 2, 2003 Office action the Examiner found the affidavit by Dr. Mikus not to be persuasive on the basis "The applicant has not provided a showing that increasing the number of heaters of Mikus in Ruhl would not provide heat sufficient to operate said process" and that "mere arguments and conclusory statements, which are unsupported by factual evidence are entitled to little probative value" citing *In re Lindner*, 457 F.2d 506, 508, 1733USPQ 356, 358 (CCPA 1972).

In Appellant's February 27, 2003 Response After Final Rejection, Appellant pointed out that Dr. Mikus' affidavit was supported by factual evidence, i.e., that the heat flux profile required for an endothermic chemical process such as the production of ethylene by the thermal cracking of hydrocarbons (3,500 to 7,000 watts per foot) is an order of magnitude greater than the heat flux required to heat subterranean formations (375 watts per foot). These facts explain why it would not have been obvious to one skilled in the art to attempt to use flameless distributed combustion heat injectors to provide heat to chemical process applications, and why it was very surprising and quite unexpected to Dr. Mikus and his co-inventors that new flameless distributed combustion process heater worked as well as it did. In their Response After Final Rejection, Appellant pointed out that since Dr. Mikus' statements were supported by facts, the rationale of

In re Lindner cited in the Office action didn't apply, and that Dr. Mikus' Affidavit should be given appropriat weight.

In the March 21, 2003 Advisory Action, the Examiner acknowledged that the Affidavit by Dr. Mikus contained factual information relating to the order of magnitude difference in heat flux requirements, but continued to maintain that it was not persuasive because the "Affidavit does not provide any data showing increasing the number of heaters of Mikus in the process of Ruhl would not provide heat sufficient to operate said process".

Appellant submits it is error for the Examiner to refuse to give appropriate weight to Dr. Mikus affidavit unless Appellant makes a showing that increasing the number of heaters of Mikus in the process of Ruhl would not provide heat sufficient to operate the process in Ruhl. Such a showing is not required by the facts in this case or the applicable law for the reasons set forth below.

1. There is no suggestion or motivation in the references for replacing the heater in Ruhl with the heater injector of Mikus, since the heaters used in both Figs. 1 and 4 of Ruhl are designed to provide non-uniform heat along the length of the burner as previously discussed, while the heater in Mikus is designed to provide even or uniform heat along the length of the burner.

2. Even if Appellant wanted to make a showing it is not clear how a showing of the type suggested by the Examiner could be made. A typical heat injector of Mikus could be hundreds, if not thousands, of feet in length, with a combustion air conduit of about 3 to 4 inches in diameter, a combustion gas conduit of about 3 to 4 inches in diameter and one or preferably two fuel conduits of about 3/4 inch in diameter, with fuel nozzles in the lower end of the fuel conduit, sized to provide a nearly uniform temperature profile within the wellbore (Col. 9, lines 3-11). On the other hand, the combustion tubes employed in the apparatus of Ruhl may have a length of 20 feet and a 0.4 inch inside diameter (Ruhl pg. 6, line 23) and will have the fuel tube with a single nozzle at the end of the tube in the case of the heater in Fig. 1 of Ruhl.

In view of these significant differences between the combustion tubes in Ruhl and the heat injectors of Mikus, it is not clear how a showing could be made. Obviously a great deal more is involved than merely increasing the number of heat injector tubes in order to achieve an order of magnitude increase in heat flux. The length, diameter, nozzle sizing and spacing and even the location of the nozzles on the fuel conduit would have to be substantially modified in order to try to adapt the heat injectors of Mikus to the reaction apparatus of Ruhl. Moreover, even if the Mikus heat injectors were physically modified to fit into the reaction apparatus of Ruhl, they would still produce "a nearly uniform temperature profile" instead of the non-uniform temperature profile desired by Ruhl in order to permit the use of low temperature seals. Therefore, a showing of the type requested in the Office action would be difficult, if not

impossible, to make without significantly modifying the heat injectors of Mikus in a way not suggested by the references themselves.

3. At best, in view of the order of magnitude difference in heat flux required to conduct endothermic chemical reactions, one skilled in the art might find it obvious to try to incorporate multiple heat injectors of the type disclosed by Mikus into the endothermic reaction apparatus of Ruhl. However, "obvious to try" is not the standard of 35 U.S.C. § 103. *In re Gieger*, 815 F.2d 686, 2 U.S.P.Q. 1276 (Fed. Cir. 1987).

Miscellaneous Positions Taken by Examiner and Appellant's Response to Those Positions

At the bottom of page 12 of the January 2, 2003 Office action the Examiner states:

> "It is the Examiner's position that, since there is a multitude of variables which can be adjusted in any heater operation to change heat flux of said heater, said variables including the flow rates of gases being burned, composition of fuel being burned, the tube design (materials of construction, length and diameter), heat transfer properties of material being heated, number of heaters, etc. it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the flameless heater of Mikus in any process which requires uniform heat transfer, such as the process of Ruhl, and if necessary to modify the operation of said heater, possibly by varying some of the aforementioned variables, to provide whatever heat is required by said process. This is suggested by the reference of Ruhl itself, which teaches that the apparatus can incorporate as many heater tubes as necessary to provide heat required by the process (see P5/L36-40)". (emphasis added)

As discussed in the previous sections, the burners in the endothermic reaction apparatuses in Figs. 1 and 4 of Ruhl do not provide uniform heat transfer. The temperatures in the "flame zone" in Fig. 1 and the "burner zone" in Fig. 4 will be higher than the temperatures in the upper and lower portions of combustion tube to permit the use of low temperature seals and a low temperature plug for the feed tube in the case of Fig. 4. Thus, contrary to the above statement in the January 2, 2003 Office action, Ruhl does not require (or even desire) uniform heat transfer. Therefore, there is no motivation or suggestion provided in the references for placing the flameless heater of Mikus (which produces an even temperature distribution along the length of the burner) into the reaction apparatus of Ruhl utilizes a burner having a non-uniform temperature along the length of the burner.

Moreover, Ruhl's teaching that the reaction apparatus can incorporate as many heater tubes as necessary to provide the heat required by the process, clearly refers to as many of the heater tubes of the type disclosed in Ruhl (which in the case of Fig. 1 has a single fuel nozzle and a large "flame zone" which would be expected to produce a relatively high heat flux). There

is nothing in Ruhl which suggests that using multiple heater injectors of the type disclosed in Mikus (which do not have a flame and which produce a relatively low heat flux) will provide the heat necessary for Ruhl's endothermic chemical processes.

It basic patent law that the mere fact that references can be combined or modified does not render the resultant combination obvious unless there is a suggestion or motivation in the references for their combination. *In re Mills*, supra.

Since Ruhl does not require or desire a uniform heat transfer along the length of the burner, there is no suggestion or motivation provided by the references to replace the heater in Ruhl with the heater of Mikus.

The fact that there may be "a multitude of variables" which could be modified or manipulated by one skilled in order in order to meet the claimed invention is not sufficient by itself to establish *prima facie* obviousness without some objective reason to combine the teachings of the references. *Ex parte Levengood*, 28 USPQ 1300 (Bd. Pat. App. & Inter. 1993).

On page 10 of the January 2, 2003 Office action it is stated that it would have been obvious to one having ordinary skill in the art "to add additional nozzles to the fuel conduit". As discussed above, the present invention clearly involves more than the addition of a few fuel nozzles to fuel conduit in the heat injector of Mikus. By utilizing a fuel conduit containing a plurality of fuel nozzles along substantially the entire length of the oxidation chamber, Appellant's process heater is able to provide a controlled heat flux to the process chamber, at a desired temperature profile and a rate sufficient to complete the reaction being conducted therein. This concept is totally lacking in Mikus, which is not concerned with endothermic chemical reactions and does not even have a process chamber.

Regarding the comments on pages 10 and 11 of the January 2, 2003 Office action concerning claims 2-4 and claims 5-6, 13, 16 19-21, Appellant does not rely on the additional limitations contained in these claims for patentability over Ruhl in view of Mikus. Appellant submits that these claims are patentable over Ruhl in view Mikus for all of the reasons discussed above.

Regarding the comments on page 11 of the January 2, 2003 Office action concerning claims 1-7, 13-16 and 18-23, Appellant is not relying on the manner in which the claimed apparatus is intended to be employed to distinguish the claimed apparatus from the prior art apparatus satisfying the claimed structural limitations. Ruhl does not satisfy the claimed structural limitations in that reaction apparatus in Fig. 1 of Ruhl does not have a plurality of fuel nozzles. While the apparatus in Fig. 4 has a plurality of fuel nozzles, the nozzles are not distributed along substantially the entire length of the oxidation chamber. Mikus does not satisfy the claimed structural limitations in that the burner apparatus in Mikus does not have a process chamber, also does not have a plurality of nozzles along substantially the entire length of the

oxidation chamber. Thus, Appellant is relying on structural limitations to distinguish the claimed process heater apparatus and not the manner in which it is intended to be used.

On the last line of the March 21, 2003 Advisory Action it is stated:

> "Further the examiner would like to point out that actual heat flux or any specific processes are not actually recited in the independent claims."

While actual heat flux values and specific processes are not recited in the independent claims, Appellant submits there are several other limitations recited in these claims which are believed to clearly distinguish the flameless distributed combustion process heater of the present invention from the relatively low heat flux heat injectors disclosed in Mikus. For example, in claim 1 it is stated that the claimed process heater is "<u>for high temperature reactions</u>", and that the "process chamber is in a heat exchange relationship with the oxidation chamber whereby a controllable heat flux is provided to the process chamber <u>at a sufficiently high rate to complete the process being conducted therein</u>" (emphasis added). Claim 18 also specifies the process heater is for "<u>high temperature reactions</u>" and that the plurality of nozzles "are sized to provide the desired temperature distribution within said process chamber and <u>the heat flux necessary to complete the process being conducted therein</u>" (emphasis added). The aforementioned limitations are believed to distinguish the claimed process heater apparatus from the heat injectors of Mikus which are not used to provide heat to high temperature reactions, and which produce heat fluxes in the range of 375 watts/ foot which not be sufficient to "complete the process being conducted in the process chamber". As previously noted, the Mikus apparatus doesn't even have a process chamber.

For all the foregoing reasons it is submitted that claims 1-7, 13-16 and 18-23 are patentable over Ruhl in view of Mikus. Accordingly, the rejection of these claims should be reversed.

THE REJECTION OF CLAIMS 17 AND 24 UNDER 35 USC 103(a) OVER RUHL IN VIEW OF MIKUS AND FURTHER IN VIEW OF MINET ET AL

In the Office action mailed January 2, 2003, the Examiner finally rejected claims 17 and 24 under 35 U.S.C. §103 (a) as being unpatentable over Ruhl in view of Mikus and further in view of Minet et al. This rejection is untenable for the reasons discussed below and should be reversed.

The Minet et al Reference Taken as a Whole

Minet et al discloses a compact, concentric tube, catalytic reaction apparatus for converting a distillable hydrocarbon feedstock or methanol into useful industrial gases, such as hydrogen and carbon monoxide. The burner used in the apparatus of Minet et al is an infrared burner which provides a uniformly radiating source for heat transfer from the burner chamber (12 in Fig. 1) to the reaction chamber (14 in Fig. 1). Hot product gases flow from upper portion of reaction chamber 14 to regenerative heat transfer chamber 16 and are used to provide heat to the reaction chamber wall thereby providing endothermic reaction heat to the counter current flowing reactant mixture within the reaction chamber. (Col. 5, lines 60-68). The oxidant (burner air) used in the infrared burner of Minet et al is introduced to the burner assembly through burner air inlet nozzle 42 where it is mixed in zone 41 with burner fuel introduced through burner fuel nozzle 44. The premixed burner air and burner fuel flows upwardly into the burner stock chamber 46 and thereupon passes to the radiant burner core 40. The air and fuel mixture effuses laterally through the radiant burner skin whereupon combustion occurs thereby providing uniform or substantially uniform radiant heat to the reaction chamber (Col. 4 lines 3-19).

Unlike the burner in the apparatuses of Ruhl, or the heat injector of Mikus, or the flameless distributed combustion process heater of the present invention, the infrared heater in Minet et al <u>does not utilize preheated air</u>. Heat is transferred from the hot product gases to the "reactants" in reaction chamber 14 by flowing the hot product gases through the regenerative heat transfer chamber 16 (Col. 6, lines 16-35). The "reactants" which are heated in this manner are <u>steam and a reformable feedstock.</u> There is absolutely no disclosure in Minet et al of using the effluent from the reaction chamber to <u>preheat the oxidant</u>. In fact, there is no indication the oxidant (burner air) used in the catalytic reaction apparatus of Minet et al is preheated, or needs to be preheated.

The Examiner's Position re Minet et al

On page 12 of the January 2, 2003 Office Action the Examiner states:

> "Regarding claim 17 and 24, Ruhl in view of Mikus disclose all of the claim limitations as set forth above, additionally the reference discloses that the oxidant can be preheated by any means known to one of ordinary skilled artisan (P5/L41-46), but the reference does not disclose that said oxidant is preheated by effluent of the process chamber.
>
> Minet et al teaches a reaction chamber, wherein the reactants are preheated by the effluent of said reaction chamber (Fig. 1 and C5/L60-68).
>
> It would have been obvious to one skilled in the art at the time the invention was made to use the hot effluent of the process chamber of Ruhl to preheat the oxidant, as taught by Minet et al, for the purpose of optimizing the process operation by effluent using heat which is available in the process for the required oxidant preheating. In this way the operation cost can be lowered because no additional source of heat is needed to preheat said oxidant"

Appellant's Comm nt's/Arguments in Response to Examiner's Position re Minet et al

It is submitted the statement in the Office action that "the reference discloses that the oxidant can b preheated by any means known to one of ordinary skilled artesian" is overly broad and inaccurate. (Appellant assumes "the reference" in the above statement refers to Ruhl reference. However, in the paragraph in middle of page 2 of the March 21, 2003 Advisory Action, the above statement is attributed to Mikus, which is believed to be in error). Assuming Ruhl is the correct reference, the relevant portion of the disclosure on page 5 of Ruhl, lines 44-46 of Ruhl reads as follows:

> "Also, it may be desirable to preheat the air fed to the heat generating means. Although no preheater is illustrated, such devices are known in the art and are commercially available. If desired, exhaust flow could be expanded (with possibly some added heat) through a gas turbine to drive the air compressor". (emphasis added)

A fair interpretation of this disclosure in Ruhl is that that any known preheater device can be used to preheat the air fed to the heat generating means and that a number of such preheater devices are available commercially. Ruhl does not disclose that any means known to one of ordinary skill in the art can be used to preheat the air, as stated in the January 2, 2003 Office action, and certainly does not disclose using product gas from the reaction vessel for preheating the oxidant.

Mikus can not reasonably be said suggest preheating the oxidant with effluent from a process chamber, since the heat injector in Mikus does not even have a process chamber, nor is there any process effluent, as previously discussed.

Thus, the Examiner cites Minet et al claiming that it would be obvious "to use the hot effluent of the process chamber of Ruhl to preheat the oxidant, as taught by Minet et al" (emphasis added). In Appellant's February 27, 2003 Response After Final Rejection, Appellant pointed out that this statement was simply incorrect, in that Minet et al taught using the process effluent to transfer heat to the reactants in reaction chamber 14. Not to preheat the oxidant. In fact, the oxidant (burner air) in Minet et al was not preheated at all.

In the March 21, 2003 Advisory Action, the Examiner insisted that she never stated that Minet et al taught using hot effluent from the process to preheat oxidant, although it's difficult to interpret the above quoted statement any other way. Instead, the Examiner said she was relying on Minet et al's teaching of using effluent from the process to preheat the reactant mixture, to somehow render obvious the use of process effluent to preheat the oxidant, although the oxidant in Minet et al is not preheat d, nor is there any reason to preheat it since it is being used in an infrared burner which does not require preheating to above the autoignition temperature.

Appellant submits that Minet et al reference adds nothing relevant to the disclosures of Ruhl and Mikus which would render obvious the subject matter of claims 17 and 24.

Since Ruhl does not disclose that the oxidant can be preheated by any known means, and since Minet et al does not disclose preheating of the oxidant with effluent from the reaction chamber, nor that the oxidant even need be preheated, these references do not provide a teaching, suggestion, or motivation for their combination, and do not support the Examiner's position stated in the March 21, 2003 Advisory Action that it would be obvious on the basis of these references "to use the hot effluent of the process chamber of Ruhl to preheat the oxidant".

On page 12 of the January 2, 2003 Office action it is stated:

> "Regarding claims 17 and 24 it has been held that a recitation with respect to the manner in which a claimed apparatus is intended to be employed does not differentiate the claimed apparatus from a prior art apparatus satisfying the claimed structural limitations. *Ex parte Masham*, 2 USPQ2d 1647 (1987)."

In response, it is pointed out that Appellant is not relying on the manner in which the claimed apparatus is intended to be employed to distinguish the claimed apparatus from the prior art apparatus satisfying the claimed structural limitations. Ruhl does not satisfy the claimed structural limitations in that reaction apparatus in Fig. 1 of Ruhl does not have a plurality of fuel nozzles. While the apparatus in Fig. 4 has a plurality of fuel nozzles, the nozzles are not distributed along substantially the entire length of the oxidation chamber. Mikus does not satisfy the claimed structural limitations in that the heat injector apparatus of Mikus does not have a process chamber, and also does not have a plurality of nozzles along substantially the entire length of the oxidation chamber. Minet et al does not satisfy the claimed structural limitations in that it employs an infrared burner to provide heat to the reaction chamber. The infrared burner in Minet et al does not have a fuel conduit with a plurality of fuel nozzles and does not have a preheater for the oxidant. Thus, Appellant is relying on the structural limitations in claims 17 and 24 to distinguish the claimed process heater apparatus, and not the manner in which it is intended to be used.

SUMMARY

In summary, claim 1 (and the claims depending therefrom) contain the limitations that the fuel conduit contain a plurality of fuel nozzles along substantially the entire length of the oxidation chamber which provides a controllable heat flux to the process chamber at a sufficiently high rate to complete the process being conducted therein. Claim 18 (and the claims depending therefrom) contain the limitations that the fuel conduit contain a plurality of fuel nozzles along substantially the entire length of the oxidation chamber and that said nozzles are

sized to provide the desired temperature distribution within said process chamber and the heat flux necessary to complete the process being conducted ther in. In view of these limitations, the present claims are believed to be patentable over Ruhl, either alone or in combination with Mikus and/or Minet et al for the following reasons:

1. Neither Ruhl nor Mikus explicitly disclose distributing a plurality of fuel nozzles along substantially the entire length of the oxidation chamber. (This is acknowledged on page 6, lines 3-4 and page 10, lines 5-6 of the January 2, 2003 Office action.) The reaction apparatus in Fig. 1 of Ruhl does not even have a plurality of fuel nozzles. While the apparatus in Fig. 4 of Ruhl has a plurality of fuel nozzles, the nozzles are not distributed along substantially the entire length of the oxidation chamber. Ruhl in fact teaches away from the concept of distributing the fuel nozzles along substantially the entire length of the oxidation chamber, in that the single fuel nozzle in the case of the apparatus of Fig. 1 is located in the "flame zone" of the combustion zone, while the plurality of nozzles in the case of Fig. 4 are all located in the "burner zone". Both the "flame zone" and the "burner zone", which have the highest temperatures, are located in the middle portion of the combustion tube, which represents a minor portion of the overall length of the combustion tube. The upper and lower portions of the combustion tube in Ruhl have no fuel nozzles and, thus, will have lower temperatures than the middle portion of the combustion tube. This allows for the use of lower temperature seals where the combustion tube is joined to the tube sheets, which is an important feature of Ruhl's reactor design.
2. One of ordinary skill in the art following the teachings of Fig. 1 of Ruhl would use combustion with flames in a "flame zone" located in the middle portion of the combustion tube, and would use a fuel tube with a single nozzle at the end of the fuel tube. (In the case of Fig. 4 of Ruhl, which is not relied by the Examiner, a plurality of fuel nozzles would be located in the "burner zone", which is also in the middle portion of the combustion tube.) One skilled in the art would following the teachings of Fig. 1 or Fig. 4, also would want lower temperatures in the upper and lower portions of the combustion tube in order to permit the use of low temperature seals. The significant benefits achieved by locating the fuel nozzles along substantially the entire length of the oxidation chamber in order to provide a controlled heat flux to the process chamber at a sufficiently high rate to complete the process being conducted therein is taught in Appellant's patent application, not in the prior art. Therefore, the use of this teaching as a basis for the rejection would be impermissible hindsight reconstruction. *Hodosh v Block Drug Co. Inc.* 786 F.2d 1136, 1143 n.5 USPQ 182 n.5 (Fed. Cir. 1986).
3. The Examiner's position that it would be obvious "to replace the heater in

the apparatus of Ruhl with the heater of Mikus for the purpose of providing more even temperature distribution throughout the length of th burner and lowering the costs of said burner" is based on the erroneous assumption that an "even" or "uniform" temperature distribution throughout the length of the burner, which is taught by Mikus to be beneficial and reduce the costs of heating subterranean formations, is also beneficial in the endothermic reaction apparatus of Ruhl. This assumption is not correct, and in fact contrary to the disclosure in Ruhl. As discussed above, the burner in Ruhl produces non-uniform heat transfer in that the middle portion of the combustion tube (which contains the "flame zone" or "burner zone" in which all of the fuel nozzles are located) is at a higher temperature than the upper portion or lower portions the combustion tube which come in contact with the low temperature seals. Thus, it would not be obvious to replace the heater in Ruhl with the heat injector of Mikus for the purpose of providing an "even" or "uniform" heat transfer along its length. Since the combustion tube in Ruhl is not designed to produce a uniform temperature (nor is an "even" or "uniform" temperature desired), there is no motivation or suggestion provided by the references to replace the heater in Ruhl with the heater of Mikus. Absent such motivation or suggestion in the references themselves for their combination, it is not appropriate to attempt to modify the references to meet the claimed invention on the basis the general knowledge or capabilities of one skilled in the art. *Ex parte Levengood*, 28 USPQ 1300 (Bd. Pat. App. & Inter. 1993).

4. Mikus does not disclose a "process heater" as this term is used in the present specification and claims. The term "process heater" as used in the present specification and claims refers to a heater used to provide a controlled heat flux to an endothermic process conducted in a process chamber. The "process chamber" is an essential element of the Appellant's process heater apparatus and this term appears as a limitation in each of the appealed claims. The heat injector in Mikus has no "process chamber". It is simply used to inject heat into underground formations to enhance oil recovery.

5. The affidavit by Dr. Mikus does contain factual evidence, i.e., that the heat flux required for a typical endothermic chemical process such the production of ethylene by the thermal cracking of hydrocarbons is 3,500 to 7,000 watts per foot, compared to 375 watts per foot required to heat subterranean formations. This order of magnitude difference between the heat flux produced by the heat injectors in Mikus and the much higher heat flux required by typical endothermic chemical processes, explains why the success of the flameless distributed combustion process heater was very surprising and quite unpredictable to Dr. Mikus and his co-inventors. Since Dr. Mikus' statements are supported by factual evidence, it was error for the Examiner not to give them appropriate weight.

6. The showing requested by the Examiner "that increasing the number of heaters of Mikus in the process of Ruhl would not provide heat sufficient to operate said process", is not required in this case because there is no suggestion or motivation in the references themselves for replacing the heater in Ruhl with the heat injector in Mikus. Moreover, since the heat injector in Mikus has significantly different dimensions than the combustion tube in Ruhl, the heat injector would have be substantially modified in order to fit into the reaction apparatus of Ruhl. Also, the location of the nozzles in the heat injector of Mikus would have to be modified, otherwise they would produce "a nearly uniform temperature profile" instead of the non-uniform temperature profile desired by Ruhl. Therefore, a showing of the type requested by the Examiner is not needed, and would be difficult, if not impossible, to make without significantly modifying the heat injectors of Mikus in a way not suggested by the references themselves. At best, in view of the order of magnitude greater heat flux required to conduct endothermic chemical reactions, one skilled in the art might find it obvious to try to incorporate multiple heat injectors of the type disclosed by Mikus into the endothermic reaction apparatus of Ruhl. However, "obvious to try" is not the standard of 35 U.S.C. § 103. *In re Gieger,* 815 F.2d 686, 2 U.S.P.Q. 1276 (Fed. Cir. 1987).

7. Ruhl's teaching that the reaction apparatus can incorporate as many heater tubes as necessary to provide the heat required by the process, clearly refers to as many of the heater tubes of the type disclosed in Ruhl (which in the case of Fig. 1 has a single fuel nozzle and a large "flame zone" which would be expected to produce a relatively high heat flux). There is nothing in Ruhl which suggests that using multiple heater injectors of the type disclosed in Mikus (which does not have a flame and which produces a relatively low heat flux) will provide the heat necessary for Ruhl's endothermic chemical processes.

Dependent claims 17 and 24, contain the additional limitation that "the oxidant is preheated by heat exchange with effluent from the process chamber". These claims are believed to be patentable over Ruhl in view of Mikus and further in view of Minet et al for the following reasons:

1. The statement in the January 2, 2003 Office action that the Ruhl "reference discloses that the oxidant can be preheated by any means known to one of ordinary skilled artesian" is overly broad and inaccurate . What Ruhl in fact discloses is that any known preheater device can be used to preheat the air fed to the heat generating means and that a number of such preheater devices are available commercially. Ruhl does not disclose that any means known to one of ordinary skill in the art can be used to preheat the air.

2. The statement on page 12 of the January 2, 2003 Office action that it

would have been obvious to one of ordinary skill in the art at the time the invention was made "to use the hot effluent of the process chamber of Ruhl to preheat the oxidant, as taught by Minet et al", erroneously implies that Minet et al teaches heating the oxidant with process effluent. This is not case. Minet et al uses the hot effluent from th process to transfer heat to the reactants (steam and reformable feedstock) in reaction chamber 14. There is no teaching or suggestion in Minet et al of using the process effluent to preheat the oxidant. In fact, the oxidant (burner air) in Minet et al is not even preheated. Since Minet et al uses a totally different burner (an infrared burner) than Ruhl, a significantly different reactor design, and since the oxidant in Minet et al is not preheated at all, it is difficult to see how the Examiner can contend that it would be obvious from the teachings of Minet et al to use the hot effluent from the process chamber of Ruhl to preheat the oxidant. Preheating of the oxidant with effluent from the process chamber is not taught in any of the cited references, but only in Appellant's own application, which, of course, cannot be used as a basis for the rejection.

For all the foregoing reasons, and in view of the affidavit submitted by Dr. Mikus, it is submitted that claims 1-7 and 13-24 are patentable over the cited references. Accordingly, it is respectfully requested that the action of the Examiner in finally rejecting these claims be reversed, and the application be passed to issue.

Respectfully submitted,

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Attachment: Appendix Containing Appealed Claims

APPENDIX

Claims Under Appeal

U.S. Application No. 09/168,770

1. A process heater for high temperature reactions comprising:

an oxidation chamber, the oxidation chamber having an inlet for an oxidant, an outlet for combustion products, and a flow path between the inlet and the outlet;

a fuel conduit for transporting a fuel to the oxidation chamber, the fuel conduit containing a plurality of fuel nozzles along substantially the entire length of the oxidation chamber, each nozzle providing fluid communication from within the fuel conduit to the oxidation chamber, the fuel nozzles being spaced so that the fuel is added to the oxidation chamber at a rate that no flame results when the fuel is mixed with the oxidant flowing through the flow path in the oxidation chamber;

a preheater in fluid communication with the oxidation chamber inlet, the preheater capable of preheating said oxidant to a temperature at which when said oxidant and the fuel are mixed in said oxidation chamber, the temperature of said mixture of oxidant and fuel exceeds the autoignition temperature of said mixture; and

a process chamber in a heat exchange relationship with the oxidation chamber whereby a controllable heat flux is provided to the process chamber at a sufficiently high rate to complete the process being conducted therein, and the heat transferred from the oxidation chamber to the process chamber does not cause the temperature of the mixture of the oxidant and the fuel within the oxidation chamber to decrease below the autoignition temperature of said mixture of the oxidant and the fuel in the oxidation chamber.

2. The process heater of claim 1 further comprising a coke inhibitor injection system, the coke inhibitor injection system being in fluid communication with the fuel conduit wherein an amount of coke inhibitor is supplied effective to inhibit coke formation at fuel conduit operating temperatures.

3. The process heater of claim 1 wherein the fuel conduit is a tubular conduit essentially centrally located within the oxidation chamber.

4. The process heater of claim 3 wherein the oxidation chamber is essentially centrally located within the process chamber.

5. The process heater of claim 1 wherein the process chamber is a pyrolysis reaction chamber for the thermal cracking of hydrocarbons in the production of olefins.

6. The process heater of claim 1 wherein the process chamber contains a catalyst and is used for steam methane reforming.

7. The process heater of claim1 wherein the process chamber contains catalyst and is used for the production of styrene by the dehydrogenation of ethyl benzene.

13. The process heater of claim1 wherein the process chamber is used for an endothermic chemical reaction.

14. The process heater of claim1 wherein the process chamber is used for the vacuum flash distillation of a feed.

15. The process heater of claim 1 wherein the process chamber is a hydrocarbon distillation column reboiler.

16. The process heater of claim 13 wherein the endothermic chemical reaction is conducted in a single stage, and heat is provided to the process chamber by the oxidation chamber at a controlled temperature profile.

17. The process heater of claim 1 wherein the oxidant is preheated by heat exchange with effluent from the process chamber.

18. A flameless distributed combustion process heater for high temperature reactions comprising:

an oxidation chamber, said oxidation chamber having an inlet for oxidant and an outlet for combustion products, and a flow path between said inlet and outlet;

a fuel conduit for transporting fuel into said oxidation chamber, said fuel conduit containing a plurality of fuel nozzles distributed along substantially the entire length of said oxidation chamber, said fuel nozzles being spaced so that the flow of said fuel through said fuel nozzles results in no flame when the fuel passes through the nozzles and is mixed with said oxidant flowing through said flow path in said oxidation chamber;

a preheater in fluid communication with said oxidation chamber, for preheating said oxidant to above a temperature at which when said oxidant and said fuel are mixed in said oxidation chamber, the temperature of said mixture of said oxidant and said fuel exceeds the autoignition temperature of said mixture; and

a process chamber in heat exchange relationship with said oxidation chamber, said plurality of nozzles distributed along substantially the entire length of said oxidation chamber being sized to provide the desired temperature distribution within said process chamber and the heat flux necessary to complete the process being conducted therein.

19. The flameless distributed combustion process heater of claim 18 wherein the process conducted in said process chamber is an endothermic chemical reaction.

20. The flameless distributed combustion process heater of claim 18 wherein the process chamber is a pyrolysis reaction chamber for the thermal cracking of hydrocarbons in the production of olefins.

21. The flameless distributed combustion process heater of claim 19 wherein said endothermic chemical reaction is conducted in a single reaction stage at a controlled temperature profile.

22. The flameless distributed combustion process heater of claim 18 wherein said process chamber contains catalyst and the process conducted in said process chamber is the production of styrene by the dehydrogenation of ethyl benzene.

23. The flameless distributed combustion process heater of claim 18 wherein said process chamber contains catalyst and the process conducted in said process chamber is steam hydrocarbon reforming to convert a hydrocarbon and steam to hydrogen, carbon monoxide and carbon dioxide.

24. The flameless distributed combustion process heater of claim 18 wherein said oxidant is preheated by heat exchange with effluent from said process chamber.